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Dynamics of the Great Caucasus mountain lakes

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ABSTRACT

At present there are 1852 mountain lakes that occupy a total area of 95.8 km^2 over the Great Caucasus territory. The largest lakes are Kazenoyam, Abrau, Big Ritsa, Kelistba, Bazaleti. Most of the mountain lakes have an area <5000 m^2. These smaller lakes occupy only 11.5% of the total lake water surface. These mountain lakes are very sensitive to changes in their watersheds. Such changes are connected with climate, glaciations and river run-off. According to existing information the formation and development of glacial lakes in high-mountain areas is a consequence of climatic variability, expressed in the process of glacier degradation. The area and quantity of glaciers are decreasing year after year. Periglacial lakes are formed in favorable geomorphologic conditions where glaciers have vanished. Studies have shown that most of the periglacial lakes appeared during retrogressive phases of glaciations: 2500 – 3000 years ago and in the 19th century. Analysis of topographic maps of 1881-1910 and topographic interpretation of aerial photos from different years have shown that glaciers existed to the end of the 19th century in many places now occupied by modern glacial lakes. Lake formation in the Great Caucasus is continuing today as glaciers recede. So, over the last 50 years about 100 new periglacial lakes have appeared in the West Caucasus. Morphometric indexes of lakes also depend upon climatic conditions, as do water regime indexes. For instance, lake levels are raised when rainfall increases but so, in consequence, are depth, area, width, length of shoreline and others characteristics. It is concluded that mountain lakes are indicators of environmental changes. However, specific relationships between indicators and climate and glaciation changes for individual lakes have not been studied in enough detail to make more than this generalized conclusion.

Keywords: Lake, glacier, tarns, degradation of lake, GLOF

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INTRODUCTION

The Great Caucasus mountains extend for about 1100 km long from northwest to southeast direction (Fig. 1). The mountains are not uniform in composition. They are mostly represented by rocks of the Jurassic, Cretaceous, Paleocene, and Neogen periods. Paleozoic rocks are exposed to the west of the axis of the mountain range.

Numerous mountain lakes are widespread over the Great Caucasus territory (Fig 1). Lakes vary in their origins, size and their water regimes. At present there are 1852 lakes in a total area of 95.8 km^2. The larger lakes are Kazenoyam, Abrau, Big Ritsa, Kelistba, Bazaleti (Table 1). Most of the mountain lakes (60%) have an area <5000 m^2. These smaller lakes account for 11.5% of the total lake water surface (Efremov 1993).

LOCATION OF LAKES

Most of the lakes (78%) are situated on the northern slope of the Great Caucasus in high-mountain areas near modern glaciation areas. A clear and regular pattern of lake distribution at high-altitudes is observed here. This fact was able to identify "lake belts" at an altitude of 2500-3000 m on the northern slope and 2000-2500 m on the southern slope. River run-off begins at 2500-3000 m.

FORMATION OF THE LAKES

Most of the Caucasus lakes are of glacial (78.5%) or karst (10%) origin. Narrow (shallow gully like) tarns, depression tarns and moraine tarns were identified for the first time in Caucasus amongst glacial lakes (in the range of tarns). These tarns are different from each other by the type of dam that retains the lake water (Efremov 1984). These mountain lakes have variable morphometric characteristics that may change depending on natural factors like geo-morphological, climatic, etc. Specific characteristics of each lake's physical, chemical and biological properties also depend upon natural factors (Efremov 1993). Formation of glacial lakes in the Great Caucasus is still continuing today as glaciers recede (Fig. 2). So, over the last 50 years about 100 new periglacial lakes have been appeared in the West Caucasus (Table 2).

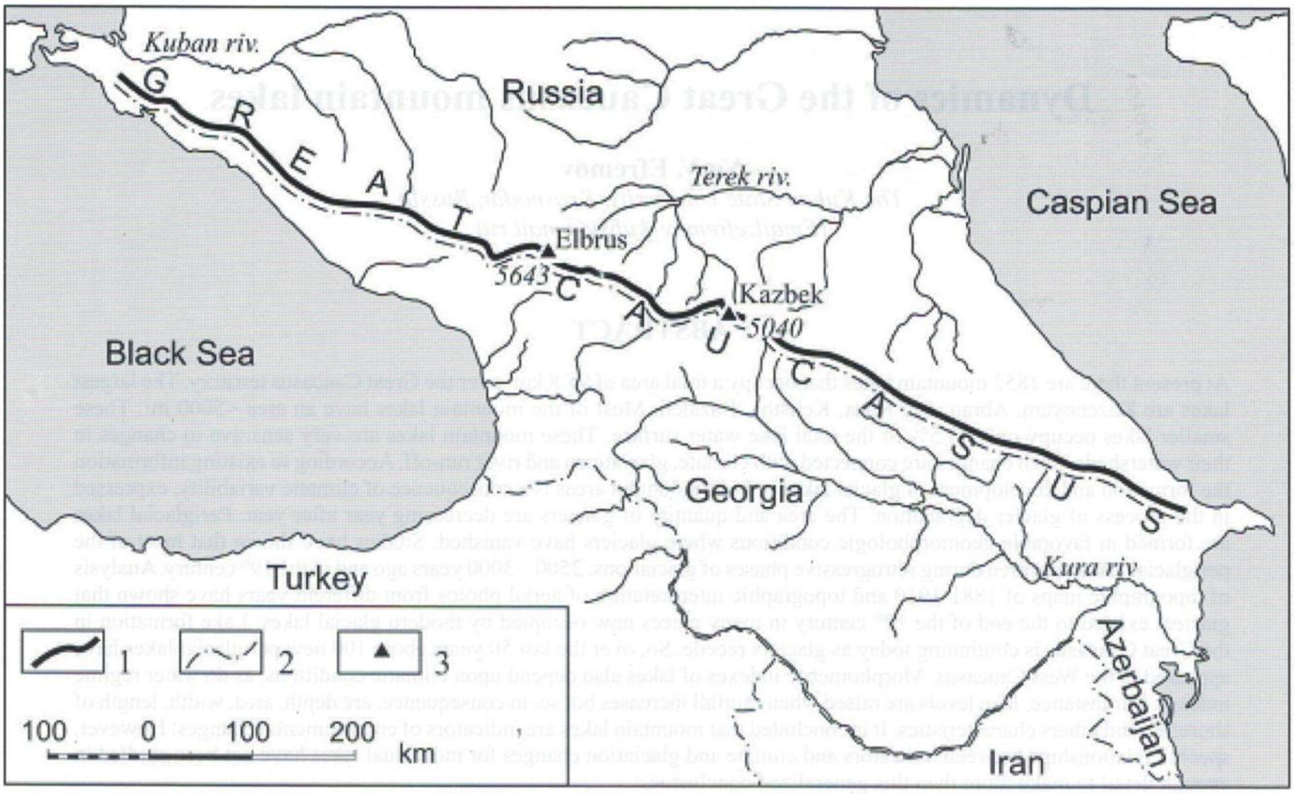

Fig. 1: The sketch of the Caucasus and location of the sites under study. 1 – the main watershed of the Big Caucasus; 2 – state frontiers; 3 – peaks

Table1: Major lakes of the Caucasus

Lake	Area (km²)	Altitude above sea level (m)	Maximum depth (m)
Kazenoyam	1.7	1870	72
Abrau	1.6	83.7	10
Big Ritsa	1.49	884	102
Kelistba	1.28	2914	63
Bazaleti	1.22	878	7

CHANGES IN GLACIAL LAKES AND THEIR SIZE

Mountain lakes are very sensitive to changes that take place in their watersheds. In this regard changes connected with climate, glaciation and river run-off are particularly important. Periglacial lakes are more sensitive to these changes than other lakes. According to existing ideas the formation and development of glacial lakes in high-mountain areas is a consequence of climatic variability, expressed in the process of glacier degradation. The area and number of glaciers are decreasing. Periglacial lakes have been formed in favorable geomorphologic conditions where glaciers have vanished. Investigations on such glaciers have shown that most of the periglacial lakes appeared during retrogressive phases of glaciation: 2500 – 3000 years ago before present and in the 19th century. Analysis of the available literatures, topographic maps of 1881-1910, and topographic interpretation of aerial photos from different years have shown that glaciers existed to the end of the 19th century in many places now occupied by modern glacial lakes.

GLACIAL LAKES AND THE GLOF

Glacial lake shorelines increase by 1.5-15 m per year as glaciers recede (Efremov et al. 1998). The glacial recession and the appearance of new periglacial lakes have a cyclical character. Periods of very intensive lake formation over the last 100 years correspond to periods of rapid glacier melting in 1890-1908, 1915-1929, 1935-1938, 1940-1955, 1960-1965 and 1975-1977 (Table 3). Similar regularities are also observed in other mountain systems. Lateral tributaries separate from a main glacier during recession and new lakes appear between them. These lakes can periodically break and that causes the Glacial Lake Outburst Flood (GLOF) to the downstream side. Good examples of such lakes are the Talsekva in Alaska (Stone 1963) and the Mertsbakhera in Tien Shan.

Periglacial lakes can be reduced in size or completely disappeared as a result of glacier activation. Few such events are known in the Great Caucasus when glaciers approached a lake area. An example is the lake situated near the edge of the East-Klukhorsky glacier lake N177 (Table 2). The lake appeared in 1880 and increased in size up to 1929. However,

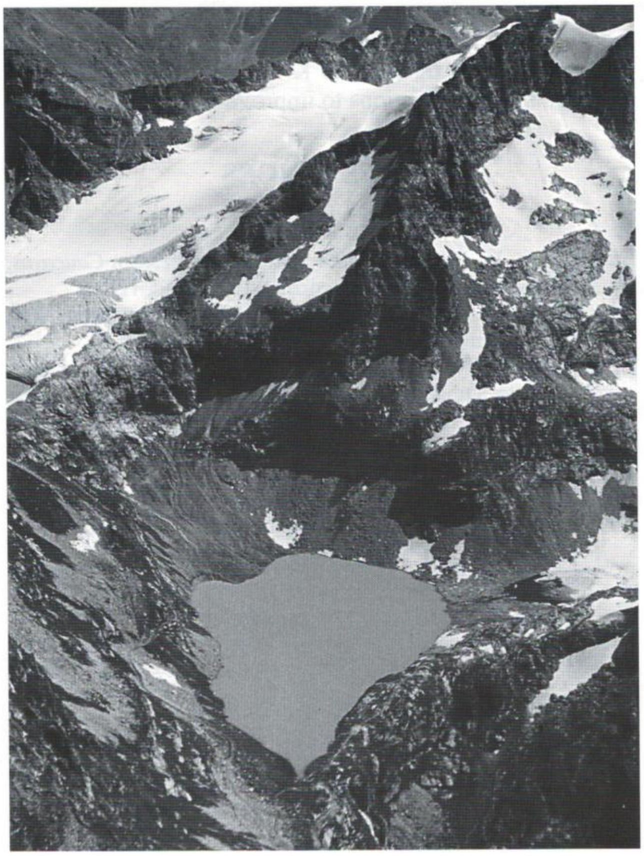

Fig. 2: The Kluchor Lake (the West Caucasus)

Fig. 3: The East-Klukhorsky Lake near a glacier (the West Caucasus)

it was almost vanished in 1935 as a result of the glacier's approach. N177 reappeared once again during 1945-1946 and it is still continued to become larger up to the present day. In some years (1977-1979, 1980-1982, 1986-1987) the area of glacier N177 decreased, coinciding with the glacier's approach (Fig. 3). Therefore, it is quite clear that the presence of periglacial lakes always indicate to the gradual degradation of glaciers.

Table 2: Information on glacial lake formation in the Caucasus high-mountain area as a result of glacier loses

Name and (or) number of the glacier/the lake	Altitude over the sea level (m)	Lake Area (approximately for 1998 in m^2)	Year when the lake appeared
Mikelchiran, N 5	3 251	15 600	1960
Birdzhalychiran, N 6	3 300	35 500	1976
Bashil, N 10	3 078	25 000	1950
Bodorku, N 21	3 000	5 700	1970
Small Azau, N 28	3 270	232 000	1950
Bashkara, N 59	2 568	53 000	1940
Ulluazna, N 64	2 500	20 600	1964
N 77	2 270	500	1975
Marukhsky, N 107	2 750	2 500	1960
East-Klukhorsky, N 177	2 980	30 310	1945
Chaulluchat, N 215	2 930	30 000	1960
N 216	2 700	6 000	1950
N 220	2 770	4 800	1960
Chingurdzhar, N 287	2 670	20 000	1960

Table 3: Surface area changes of periglacial lakes in the Great Caucasus

Lake	Observation Period	Area Changes(m^2)	Remarks
Amanauzskoe	1978-1985	+5 910	
East-Klukhorskoe	1935-1958 1958-1963 1963-1977 1977-1979 1979-1986 1986-1987 1987-1988	+ 10,820 + 3,560 + 6,380 - 1,470 +9,170 - 1,060 +2,910	
Perevalnoe	1929-1988	+ 2,500	The glacier melted in 1977
Birdzhalychiran-1	1958-1981	+ 3,900	The lake broke out in 1983
Birdzhalychiran-4	1981-1987	+ 4,200	
Birdzhalychiran-5	1958-1987	+ 32,000	
Birdzhalychiran-8	1958-1987	+ 8,800	
Mikelchiran	1981-1988	+ 8,590	
Small Azau	1981-1988	+ 6,250	
Bashkara	1984-1988	+ 4,000	
Ulluazna	1984-1986	+ 2,428	Situated near the end of the glacier

Observations conducted on several lakes in the West Caucasus (Karakel, Tumanlykel, Klukhorskoe, Zerkalnoe) have shown that there exists a straight dependency between atmospheric precipitation and water level of the lakes. A dependency between the air temperature and lake levels also exists. The levels of the periglacial lakes increase with increase of the temperature. The levels of lakes situated outside of glacial areas increase at the beginning of summer, as a result of melting of snow cover. After the snow has melted, changes in air temperature are basically reflected in the temperature of the water, but changes in lake levels are not observed in high-mountain areas. Levels of lakes situated in the middle- and low-mountain areas may sometimes decrease in summer time during stable hot weather. Morphometric indexes of lakes also depend upon climatic conditions, as do water regime indexes. For instance, lake levels are raised when rainfall increases but so, in consequence, are depth, area, width, length of shoreline and others characteristics.

CONCLUSIONS

From the present investigation results it is concluded that the mountain lakes are the good indicators of environmental changes. However, specific relationships between the indicators and climate and glaciation changes for individual lakes have not been studied in sufficient detail to make more than this generalized conclusion. It is recommended that all these available information should be taken as base for further detail investigations in future.

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